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Oxygen isotope composition of phytoliths from tropical forests: towards a new paleo-climate tool

A. Alexandre(1), J. Crespin(1), C. Sonzogni(1), D. Hilbert(2)

(1) CEREGE, CNRS UMR6635, UPCA III, Europôle de l'Arbois, BP 80, 13545, Aix-en-Provence Cedex 04, France, (2) CSIRO Tropical Forest Research Centre, PO Box 780 Atherton QLD 4883 Australia (alexandre@cerege.fr / Fax : +33 4 42 97 15 40)

Using oxygen isotope composition from phytoliths ($\delta^{18}O_{phytolith}$) as a proxy of paleo-climate (atmospheric temperature and $\delta^{18}O_{rainwater}$) would help to further satisfy the need of continental quantitative paleo-climate data.

Phytoliths are amorphous silica particles that precipitate in the cells of living plants. For a given phytolith assemblage, the morphological analysis provides information on the vegetation physiognomy. Tropical forests are easily characterized by their phytolith assemblages: one phytolith type (*Globular granulate*), produced in the secondary xylem (wood) of tropical trees and shrubs, accounts for 60 to 90% of the phytolith assemblages. Investigating phytoliths from grasses, Shahack-Gross et al. (1996) and Webb and Longstaffe (2000; 2002; 2003; 2006) were the first to demonstrate the thermo-dependency of the relationship between $\delta^{18}O_{phytoliths\,from\,stem}$ and $\delta^{18}O_{soil\,water}$. However, these studies also showed that $\delta^{18}O$ values of phytoliths from transpiring tissues (e.g. leaf epidermis) could not be used as a paleo-environmental proxy due to daily variations of $\delta^{18}O_{leaf\,water}$ values driven by evapo-transpiration. Because phytoliths from grasses'stems and leaves show similar morphology, $\delta^{18}O_{grass\,phytoliths}$ values cannot be used for paleo-environmental reconstructions. As transpiration is non-significant in the wood, $\delta^{18}O_{secondary\,xylem}$ of trees from tropical forests should be close to $\delta^{18}O_{soil\,water}$ (Ometto et al., 2005) and $\delta^{18}O_{phytoliths}$ should show a direct thermo-dependant relationship with $\delta^{18}O_{soil\,water}$ and, if soil evaporation is weak, with $\delta^{18}O_{rainfall}$. In order to verify this assumption, a calibration of the relationships between $\delta^{18}O_{phytolith,}\delta^{18}O_{rainfall}$

and atmospheric temperature is presented here.

Thirty-two soil phytolith assemblages from the Queensland rainforests (Atherton tableland, Australia) were sampled along 4 elevation, rainfall and temperature gradients. Phytolith assemblages were chemically extracted and counted at 600X magnification. After a controlled isotopic exchanged procedure, $\delta^{18}O_{phytolith}$ was analyzed using an IR-laser fluorination technique developed at CEREGE and, for the first time, successfully applied to small grain size powders made of authigenic and biogenic silica (Alexandre et al., 2006; Crespin et al., 2007). The laser fluorination technique is faster than the conventional fluorination technique and allows analysis of $\delta^{18}O$ values on small to minute samples (from 1.6 to 0.3 mg) as required for high resolution paleoenvironmental reconstructions. The long term reproducibility on $\delta^{18}O$ measurements is lower than or equal to $\pm$0.5 per mil (1SD), that leads to an estimated uncertainty on $\delta^{18}O_{phytolith}$ close to $\pm$0.5 per mil. Resulting uncertainties on reconstructed temperature and $\delta^{18}O_{forming\,water}$ are respectively $\pm$2˚C and $\pm$0.5 per mil, and fit in the precisions required for inter-tropical paleo-environmental reconstructions.

Our results show good correlations between [measured $\delta^{18}O_{phytolith}$ – estimated $\delta^{18}O_{rainfall}$] and mean annual temperature or mean monthly temperature of the rainy season (r^2=0.6). The $\delta^{18}O$ signature of phytolith assemblages from tropical rainforests is thus a good proxy of atmospheric temperature or $\delta^{18}O$ of rainfall (with $\delta^{18}O_{rainfall}$ close to $\delta^{18}O_{soilwater}$ in rainforests), provided that one of the two variables may be assumed.

The modern data set presented here can now be used as reference for interpreting $\delta^{18}O_{phytolith}$ records from northeast Australia or the Western Pacific area.